

What is claimed is:

1. A frequency-selective grating operable to produce an output pulse of electromagnetic radiation in a specified target direction from the grating in response to an input optical pulse of the electromagnetic radiation to the grating, the input optical pulse comprising a temporal waveform substantially matching an address temporal waveform encoded in the grating.
2. An optical data router, comprising a frequency-selective optical grating operable to produce an output pulse of electromagnetic radiation in a specified target direction from the grating in response to an input optical pulse of the electromagnetic radiation to the grating, the input optical pulse comprising a temporal waveform substantially matching an address temporal waveform encoded in the grating.
3. An optical data router according to claim 2 wherein the grating is a spatial grating.
4. An optical data router according to claim 2 wherein the grating is a spatial-spectral grating.
5. An optical data router, comprising an active material comprising a composite frequency-selective optical grating operable to produce an output pulse of electromagnetic radiation in a specified target direction from the grating in response to an input optical pulse of the electromagnetic radiation to the grating, the input optical pulse comprising a

temporal waveform substantially matching an address  
temporal waveform encoded in the grating.

5 6. An optical data router according to claim  
5 wherein the active material is transmissive to the  
electromagnetic radiation.

10 7. An optical data router according to claim  
6 wherein the active material has a thickness  
dimension, and the grating is defined by the material  
in the thickness dimension.

15 8. An optical data router according to claim  
7 wherein the active material is a frequency-selective  
material.

20 9. An optical data router according to claim  
8 wherein the active material is an inhomogeneously  
broadened absorber material.

10 10. An optical data router according to claim  
5 wherein the active material is a frequency non-  
selective material.

25 11. An optical data router according to claim  
10 wherein the grating is a surficial grating on the  
active material.

30 12. An optical data router according to claim  
5 wherein the grating is an index-of-refraction  
grating.

13. An optical data router according to claim 5 wherein the grating is a volume hologram.

5 14. An optical data router, comprising:  
(a) an active material; and  
(b) a composite frequency-selective optical grating programmed in or on the active material, the grating being operable to produce an output pulse of electromagnetic radiation in a specified target  
10 direction from the grating in response to an input optical pulse of the electromagnetic radiation to the grating, the input optical pulse comprising a temporal waveform substantially matching an address temporal waveform encoded in the grating.

15 15. An optical data router according to claim 14 wherein the active material is an inhomogeneous broadened absorber material.

20 16. An optical data router according to claim 15 wherein the active material is a rare-earth doped compound, the compound being selected from a group consisting of  $Y_2O_3$ , YAG,  $LaF_3$ ,  $YAlO_3$ ,  $SiO_2$ ,  $GeO_2$ ,  $B_2O_3$ , and  $P_2O_5$ .

25 17. An optical data router, comprising:  
(a) an active material;  
(b) a composite frequency-selective optical grating disposed on or in the active material;  
30 (c) a source of an optical data beam of electromagnetic radiation, the active material being disposed relative to the source so as to allow the optical data beam to impinge on the active material and

interact with the grating, and the optical data beam comprising a temporal waveform; and

- (d) the grating having a spatial-spectral structure representing an optical interference of a direction pulse and an address temporal waveform of the electromagnetic radiation, the address temporal waveform being substantially similar to the temporal waveform of the optical data beam, and the grating being operable to produce an output pulse of the electromagnetic radiation in a specified target direction from the grating in response to interaction of the temporal waveform of the optical data beam with the grating.

18. An optical data router according to claim 17 wherein the active material is an inhomogeneously broadened absorber having a thickness dimension, the grating being disposed throughout the thickness dimension of the material.

19. An optical data router according to claim 17 wherein the active material is frequency non-selective.

20. An optical data router according to claim 19 wherein the grating is disposed on a surface of the active material.

21. An optical data router, comprising an active material programmed with a composite frequency-selective optical grating responsive to an electromagnetic radiation, the grating being structured

so as encode an optical interference of a direction pulse and an address pulse of the electromagnetic radiation, the address pulse encoding a particular temporal waveform, and the grating being operable to  
5 produce an output pulse of electromagnetic radiation in a target direction, determined by the direction pulse, from the grating in response to an input optical pulse of the electromagnetic radiation to the grating, the input optical pulse comprising a temporal waveform  
10 substantially matching the address temporal waveform.

22. Use of a frequency-selective spatial-spectral grating to differentially direct an optical beam, bearing a particular temporal waveform and  
15 entering the grating from a first direction, in a predetermined second direction relative to the first direction.

23. A method for routing optical data pulses  
20 of an electromagnetic radiation, the method comprising the steps:

(a) providing a frequency-selective grating having a spatial-spectral structure encoding an optical interference of an address temporal waveform and a  
25 direction pulse of the electromagnetic radiation; and

(b) impinging an optical data beam of the electromagnetic radiation on the grating, the data beam comprising a temporal waveform substantially similar to the address temporal waveform, so as to cause the  
30 grating to produce, in response to the temporal waveform of the data beam interacting with the grating, an optical output pulse that propagates in a direction,

relative to the input pulse, defined by the direction pulse.

24. A method for routing optical data pulses  
5 of an electromagnetic radiation, the method comprising the steps:

(a) providing an active material capable of supporting an optical interference grating of an electromagnetic radiation;

10 (b) programming a grating in or on the active material, the grating providing a spatial-spectral structure corresponding to an interference of first and second pulses of the electromagnetic radiation, the first optical pulse comprising a temporal address  
15 waveform and the second optical pulse having a particular spatial direction relative to the first optical pulse; and

(c) directing an optical beam so as to impinge upon the grating, the optical beam comprising  
20 encoded data including a temporal waveform substantially similar to the temporal address waveform so as to cause the grating to produce, in response to the temporal waveform of the optical beam interacting with the grating, an optical output pulse that  
25 propagates in a direction, relative to the optical beam, defined by the second optical pulse.

25. A method according to claim 24 wherein the optical beam comprises a coded optical data stream  
30 convolved with the temporal address waveform.

26. A method of programming an inhomogeneously broadened absorber material so as to

enable the material to route a data-containing optical beam of an electromagnetic radiation to which the material is transmissive, the method comprising:

(a) exposing the material to a first temporal waveform of the electromagnetic radiation, the first temporal waveform corresponding to a desired address code; and

(b) exposing the material to a second temporal waveform of the electromagnetic radiation, the second temporal waveform defining a target direction, the first and second temporal waveforms interacting with the material so as to form a composite spatial-spectral interference grating in the material operable to produce an output pulse of the electromagnetic radiation, in the target direction, in response to an input optical pulse of the electromagnetic radiation into the grating, the input optical pulse comprising a temporal waveform substantially the same as the address temporal waveform.

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